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(54) Title: DIGITAL MOBILE COMMUNICATION SYSTEM AND METHODS FOR PROCESSING A TERMINATING CALL		
(57) Abstract <p>A radio interface is provided in packet radio system (SGSN, GGSN, 10) by means of a digital mobile communication network (BTS, BSC, MSC, HLR). A dual-mode terminal equipment (MS) is capable of operating both in the mobile state and in the packet radio state but it monitors different control channels in these states. There is information in the subscriber database (HLR) of the mobile communication network that the mobile station (MS) is not available when it is in the packet radio state. This enables call forwarding and appropriate announcements in connection with mobile-terminating calls. There may also be information in the subscriber database (HLR) that the mobile station is in the packet radio state. In that case the subscriber database (HLR) of the mobile communication network may send a notification to the mobile station (MS) via the packet radio network (SGSN, GGSN, 10) that the mobile station should transit to the mobile state for receiving an incoming call.</p>		

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Digital mobile communication system and methods for processing a terminating call

Field of the Invention

5 The present invention relates to mobile communication systems to which a packet radio network is connected.

Background of the Invention

10 Mobile communication systems have been developed as it has become necessary to make people free to move away from fixed telephone terminals without making their availability more difficult. At the same time as the use of different data transmission
15 services has increased in offices, various data services have also been introduced to mobile communication systems. Portable computers allow effective data processing wherever the user is moving. The mobile communication networks, in turn, provide the
20 user with an effective access network for mobile data transmission, the network giving access to actual data networks. For this purpose new data service modes are being designed for present and future mobile communication networks. Digital mobile communication
25 systems, such as the pan-European mobile communication system GSM (Global System for Mobile Communication) support mobile data transmission particularly well.

 General Packet Radio Service GPRS is a new service in the GSM system and it is one of the subjects
30 of standardization of GSM phase 2+ at ETSI (European Telecommunication Standard Institute). A GPRS operational environment comprises one or more subnetwork service areas which are connected to one another by GPRS Backbone Network. A subnetwork
35 comprises a set of packet data service nodes SN which

are herein referred to as serving GPRS support nodes SGSN. Each SGSN is connected to the GSM mobile communication network (typically to base station systems) so that it is able to provide a packet data service for mobile data terminal equipments via several
5 base stations, that is, cells. The intermediate mobile communication network provides packet switched data transmission between support node and mobile data terminal equipments. Different subnetworks are, in
10 turn, connected to an external data network, e.g. to a packet switched public data network PSPDN, via special GPRS gateway support nodes GGSN. Therefore by means of GPRS service the packet data transfer is provided between mobile data terminal equipments and external
15 data networks while the GSM network acts as an access network. One feature of the GPRS service network is that it operates almost independently of the GSM network beside "ordinary" GSM network services.

In the GPRS GSM network there may be mobile
20 stations MS (class B and C mobile stations) which may operate both normally in the GSM network and also in the GPRS network. In the present application the mode of operation in which the mobile station operates in the GPRS network (data transmission over a packet-switched connection, the so-called Active state in GPRS
25 terms), is referred to as GPRS state, and the mode of operation in which the mobile station operates in the GSM network is referred to as GSM state (data or speech transmission over a circuit-switched connection, the so-called Idle state in GPRS terms). The MS transits
30 from the GSM state (Idle) to the GPRS state (Active) by initiating a GPRS Logon procedure and from the GPRS state (Active) to the GSM state (Idle) by initiating a GPRS Logoff procedure. When the MS is in the GPRS state
35 (Active), it may either actively transmit and receive

messages or be "idle". As in the GPRS state the MS is most of the time idle, it may monitor normal GSM paging channels and react to circuit switched mobile terminating calls, for example. It may not be possible to monitor GSM channels during the packet data transmission. Therefore the MS may not be reached. As data transmission activity of the MS in the GPRS state is not known accurately, it is neither known exactly if the MS receives GSM pagings or not. If the MS does not receive a paging message, the GSM network may conclude the presence of a fault situation, as on the basis of subscriber data of the GSM network, the MS should be available. The normal situation will not be restored until the MS returns to GSM state (Idle). This "indefinite" availability of the MS is a problem both for a mobile subscriber and for the GSM network and the calling subscriber. A similar problem may arise also in other packet radio networks that are built on top of a conventional mobile communication network.

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Brief Summary of the Invention

One object of the present invention is to eliminate this problem.

The present invention relates to a digital mobile communication system comprising

a mobile communication network containing a mobile services switching centre, base station systems, and a subscriber database for maintaining subscriber data and location data of mobile communication network subscribers,

a packet radio network containing packet radio support nodes, each of which is connected to the mobile communication network and to one or more of the remaining packet radio support nodes, and at least one gateway support node which provides an access point for

an external data network or to another packet radio system,

5 first control channels which are allocated to the use of the mobile communication network in base station systems,

second control channels which are allocated to the use of the packet radio network in base station systems,

10 a mobile terminal equipment having a first operating state where it monitors said first control channels, and a second operating state where it monitors said second control channels. According to the invention, the subscriber database of the mobile communication network has information that the mobile terminal equipment is not available via the first control channels when the mobile terminal equipment is in said second operating state.

15 The present invention also relates to methods for processing a mobile-terminating call in a digital mobile communication system comprising a mobile communication network; a packet radio network containing packet radio support nodes, each of which is connected to the mobile communication network which provides a radio interface for the packet radio network; first control channels allocated to the use of the mobile communication network in the radio interface; second control channels allocated to the use of the packet radio network in the radio interface; and a mobile terminal equipment having a first operating state where it monitors said first control channels, and a second operating state where it monitors said second control channels.

25 The first method comprises the steps of:

30 updating in the subscriber database of the mobile communication network information on that the

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mobile terminal equipment the availability of the mobile terminal equipment via the first control channels is uncertain when the mobile terminal equipment transits to the second operating state,

5 updating in the subscriber database of the mobile communication network information on that the mobile terminal equipment is available via the first control channels when the mobile terminal equipment returns to the first operating state,

10 receiving a mobile-terminating call in the mobile communication network,

 making an inquiry into said subscriber database,

 interrupting call set-up or making call forwarding if the subscriber database contains information that the availability of the mobile terminal equipment is uncertain.

 The second method comprises the steps of:

 updating in the subscriber database of the mobile communication network information on that the mobile terminal equipment is in the packet radio network and not available via the first control channels when the mobile terminal equipment transits from the first to the second operating state,

25 receiving a mobile-terminating call in the mobile communication network,

 making an inquiry into said subscriber database,

 in response to said information in the subscriber database, transmitting a notification to the mobile terminal equipment via the packet radio network that it is about to receive a call in the mobile communication network,

30 the mobile terminal equipment transiting to monitor the first control channels in response to

receiving the notification,

continuing call set-up in the mobile communication network via the first control channels.

5 The third method comprises the step of:
maintaining in the subscriber database of the mobile communication network information on that the mobile terminal equipment is capable of operating or authorized to operate in the second operating state,

10 a mobile-terminating call in the mobile communication network,

making an inquiry into said subscriber database,

15 in response to the information in said database (HLR), transmitting a notification of an incoming call to the mobile communication network via the packet radio network to the mobile terminal equipment,

20 the mobile terminal equipment transiting to monitor the first control channels in response to receiving the notification,

the call set-up is continued in the mobile communication network via the first control channels.

25 The basic idea of the present invention is to produce information for the actual mobile communication network on that it is not completely certain that the mobile station is available for conventional calls when the mobile station is in the packet radio state. By means of the availability information, the mobile communication network is capable of giving the appropriate response (e.g. the mobile station busy or beyond the coverage area) to the calling subscriber and perform a call forwarding for MT calls, for example.

30 In one embodiment of the invention, the mobile station itself, when transiting to the packet radio state, signals to the mobile communication network that
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it is not available for conventional mobile communication services. The mobile communication network stores this availability information as normal to the subscriber data. When departing from the packet radio state, the mobile station signals to the mobile station that it is available again. This takes place preferably by conventional signalling which can be used in the mobile communication network for this purpose, such as IMSI Detach and IMSI Attach messages in the GSM system.

In the second embodiment of the invention, the mobile communication network deduces the status information of the mobile station from that the mobile station logs in to a packet radio state in a packet radio subscriber register. In that case the mobile station need not separately signal the information. Furthermore, the subscriber data may contain the reason for being unavailable, that is, the packet radio state.

These embodiments of the invention overcome the problem relating to the "indefiniteness" of the availability of a mobile station: now the mobile communication network knows unambiguously that the mobile station is not available for normal calls. However, some of the availability problem still remains, even more acutely than before: if the user holds the mobile station long in the packet radio state, he/she is not able to receive MT calls even when he/she has not transmitted even one data packet in all that time.

This problem can be further relieved in a still further embodiment of the invention. There is information in the mobile communication network that the mobile station is in the packet radio state and thus unavailable for normal calls. When in the MT call set-up, the location of the mobile subscriber is

inquired of the subscriber database, e.g. of the home location register HLR in the GSM network, the subscriber database detects that the mobile station is in the packet radio state. Then the subscriber database initiates a notification procedure in the packet radio network. In the notification procedure, the serving packet radio support node transmits on a packet radio channel a message to the mobile station for informing of the MT call in the mobile communication network. Because of this, the mobile station is aware of the incoming MT call and may start to monitor the paging channels of the mobile communication network. The mobile station or the user may have the possibility to choose whether the MT call is to be received or not.

Brief Description of the Drawings

In the following, the invention will be described in more detail with reference to the accompanying drawing, where

Figure 1 shows a GPRS network according to the invention,

Figures 2, 3 and 4 are signalling diagrams illustrating different methods for updating presence/-absence information of the mobile station in the HLR, and for processing an MT call.

Preferred Embodiments of the Invention

The present invention is suitable to be used for management of mobile-terminating (MT) calls in different types of packet radio systems where the mobile station is able to transmit between the mobile station state and the packet radio state where it does not monitor the paging channels of the mobile system or monitors them only occasionally. The invention is particularly suited for use in the implementation of

General Packet Radio Service in the pan-European digital mobile communication system GSM (Global System for Mobile Communication) or in similar mobile communication systems, such as DCS1800 and PCN (Personal Communication Network). In the following, the preferred embodiments of the invention will be explained by means of the GPRS packet radio network provided by the GPRS service and the GSM system, without restricting the invention to this specific packet radio system.

Figure 1 illustrates the GPRS packet radio network implemented into the GSM system.

The basic structure of the GSM network comprises two parts: a base station system BSS and a network subsystem (NSS). The BSS and the mobile stations MS communicate over radio links. In the base station system BSS each cell is served by a base station BTS. A set of base stations is connected to a base station controller BSC whose function is to control the radio frequencies and the channels of the BTS. The BSCs are connected to a mobile services switching centre MSC. Specific MSCs are connected to other telecommunication networks, such as public switched telephone network PSTN, and contain gateway functions for incoming calls from the networks and outgoing calls to the networks. These MSCs are known as gateway MSCs (GMSC).

There are two main types of databases associated with call routing. The home location register HLR stores the subscriber data of all subscribers of the network permanently or semipermanently, including information on the services the subscriber may have access to, and on the present location of the subscriber. Visitor location register VLR is the other register type. A VLR is generally

connected to one MSC but it may, however, serve several MSCs. It is a general practice that the VLR is integrated into the MSC. This integrated network element is known as visitor MSC (VMSC). Whenever the mobile station MS is active (registered and capable of making or receiving calls), most of the mobile subscriber data relating to the mobile station MS maintained in the HLR, is copied into the VLR of the MSC in whose area the MS is located. With regard to a more detailed description of the GSM system, a reference is made to the ETSI/GSM Specifications and to *The GSM System for Mobile Communications*, by M. Mouly & M. Pautet, Palaiseau, France, 1992, ISBN:2-9507190-0-0-7.

In Figure 1 the GPRS network connected to the GSM network comprises two serving GPRS support nodes (SGSN) and one GPRS gateway support node (GGSN). These different support nodes SGSN and GGSN are connected to one another by Intra-Operator Backbone Network. It is to be understood that the GPRS network may have any number of support and gateway nodes. It may also have so-called home support nodes HGSN although as a rule, the HGSN functions are integrated into the GGSN.

Each support node SGSN manages a packet data service in the area of one or more cells in a cellular packet radio network. For this purpose, each support node SGSN is connected to a specific local section of the GSM mobile communication system. This connection is typically made into the mobile services switching centre MSC, but in some situations it may be advantageous to make the connection directly to the base station system BSS, that is, to the base station controllers BSC or to one of the base stations BTS. The mobile station MS in the cell communicates over the radio interface with the base station BTS and further

through the mobile communication network with the support node SGSN whose service area the cell belongs to. In principle, the mobile communication network between the support node SGSN and the mobile station MS only transmits packets between these two. The mobile communication network may for this purpose provide either a circuit-switched connection or a transmission of packet-switched data packets between the mobile station MS and the serving support node SGSN. An example of a circuit-switched connection between the mobile station and the support node (Agent) is shown in Finnish Patent Application 934,115. An example of a packet-switched data transfer connection between the mobile station and the support node (Agent) is shown in Finnish Patent Application 940,314. It should be noted that the mobile communication network provides only a physical connection (access network) between the mobile station and the support node SGSN and its exact operation and structure are not of essential significance for the invention.

The intra-operator backbone network 10, which inter-connects the operator's equipments SGSN and GGSN, can be implemented by a local network, for example. It is to be noted that it is also possible to implement the operator's GPRS network without an intra-operator backbone network, for example by implementing all the features into one computer, but this modification does not cause any alterations to the principles of call set-up according to the invention.

The GPRS gateway support node GGSN inter-connects the operator to the GPRS network of the other operators of the GPRS network and to data networks, such as Inter-Operator Backbone Network 12, IP network or X.25 network 11. An interworking function IWF may be located between the gateway support node GGSN and other

networks. The backbone network 12 between the operators is a network via which the gateway support nodes GGSN may communicate with each other. This communication is required to support GPRS roaming between different GPRS networks.

The gateway support node GGSN is also used for storing the location information of the GPRS mobile station. The GGSN also routes mobile-terminating (MT) data packets. The GGSN also contains a database which maps together the network address of the mobile station, e.g. in IP network, in X.25 network, in CLNP network or simultaneously in several of them and the mobile station identifier in the GPRS network. When the mobile station moves from one cell to another within the area of one support node SGSN, location updating must be done only in the support node SGSN and there is no need for informing the GGSN of the change of location. When the mobile station moves from one cell of the support node SGSN to another SGSN cell in the area of the same or different operator, updating is carried out also for the (home) gateway support node GGSN for storing the new visitor support node identifier and the mobile station identifier.

The GPRS register GR is used for authenticating the subscribers at the beginning of a GPRS session. It contains a mapping between the packet data protocol (PDP) address (addresses) of the subscriber and the IMSI (International Mobile Subscriber Identity) of the subscriber. In the GSM network the subscriber is identified by means of the IMSI. The GR may be a separate register or it may be preferably integrated into the home location register HLR in the mobile communication system. In Figure 1 the HLR/GR is connected via the SS7 (Signalling System 7) to the MSC and the intra-operator backbone network.

There may be a direct connection or an SS7 gateway node GATEWAY between the SS7 signalling system and the intra-operator backbone network. In this way the HLR/GR may in principle exchange packet-switched messages with any GPRS node. The communication method of the HLR/GR and the connection between the GPRS network is not, however, essential for the invention. Alternatively, there may be, for example, a direct connection to one of the nodes, or the GR is one node in the GPRS network.

When the MS transits to the GPRS state (where data can be transferred over a packet-switched connection), it initiates the GPRS Logon procedure. In the procedure, the MS requests access to the GPRS network and sends its identity IMSI to the serving support node SGSN. The serving SGSN makes an inquiry into the HLR on the basis of the IMSI. The HLR initiates a GSM type of challenge-response authentication in the packet radio network. This includes generation and sending of an authentication triplet to the GPRS network. After authentication, the MS registers as the user of a specified data network (such as 11) and its address. This registration is performed along with the GR.

In the GPRS GSM network there may be mobile stations MS (class B or C mobile stations) which may be either in the GPRS state or in the GSM state (data or speech transmission over a circuit-switched connection). The MS transits from the GSM state to the GPRS state by initiating the GPRS Logon procedure and from the GPRS state to the GSM state by initiating the GPRS Logoff procedure. As the MS is in the GPRS state most of the time idle, it could still monitor normal GSM pagers (e.g. for setting up a mobile-terminating (MT) speech call), but it cannot be guaranteed that the MS will receive the paging messages. If the MS does not

receive the paging message, the GSM network may deduce the presence of a fault situation as the MS should be available according to the subscriber data in the GSM network. The normal situation will not be restored until the MS returns to the GSM state.

5 In the present invention, information is produced in the home location register HLR of the GSM network on that the mobile station is not available for ordinary calls when it transits to the packet radio state. By means of this information, the mobile communication network is able to give an appropriate response (e.g. the mobile station busy or beyond the coverage area) to the calling subscriber and to perform call forwarding in MT calls or to interrupt call set-up. The signalling diagrams of Figures 2 and 3 show an example of two alternative methods for updating presence/absence information of the mobile station in the HLR and for processing an MT call.

10 In the embodiment of Figure 2, the MS itself is arranged, before transiting to the packet radio state, to signal to the GSM network that it is not available for conventional mobile services. This takes place e.g. by an IMSI Detach message according to GSM recommendations that is normally used for informing that the MS has departed from the network (e.g. as a result of the mobile station being switched off). This message does not normally contain information on the reason of absence but it can be provided with this information when required. The MS signals an IMSI Detach message on the GSM channel via the base station system BSS to the mobile services switching centre MSC that forwards the IMSI Detach information to the HLR. The HLR updates in the subscriber data that the mobile subscriber (MS) is not available (MS Detached).

15 20 25 30 35 After this, the MS performs on the GPRS

channel registration to the GPRS network with the GPRS Logon procedure. In this way the MS has transitted from the GSM state to the GPRS state where it monitors primarily or solely GPRS channels.

5 An MT call is received at the MSC from the public switched telephone network, for example. The MSC makes a normal routing data inquiry into the HLR (an HLR inquiry). The HLR detects from the subscriber data that the MS is not available and signals this information in response to the MSC. The MSC gives an appropriate announcement to the calling subscriber and terminates call set-up or performs a call forwarding, for example. The information on the activated call forwarding and the call forwarding number are obtained
10 in the response of the HLR.
15

 At some stage the MS terminates the registration to the GPRS network by carrying out a GPRS Logoff procedure on the GPRS channel. When transiting back to the GSM state, the MS signals once more to the GSM network that it is available again. This takes place by an IMSI Attach message according to the GSM recommendation, for example. The MS sends an IMSI Attach message on the GSM channel via the base station system BSS to the MSC which forwards the IMSI Attach information to the HLR. The HLR updates in the subscriber data information on that the mobile subscriber (MS) is available (MS Attached). The MT calls received after that are processed as in normal call set-up in the GSM system.
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30 According the second embodiment of the invention, absence information is produced in the HLR in another way which does not require that the MS signals separately the information on GSM channels. Instead, the HLR receives information via the GPRS network. There are several alternatives for this, some
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of which are shown in the following.

1) The MS itself signals the information directly to the HLR in a data packet (GPRS IMSI Attach, GPRS IMSI Detach).

5 2) The MS signals the information to the SGSN (e.g. GPRS Logon, GPRS Logoff) which informs it further to the HLR.

 3) The MS signals the information to the SGSN (e.g. GPRS Logon, GPRS Logoff) which informs it further to the GR and the GR to the HLR.

10 4) The MS signals the information to the SGSN (e.g. GPRS Logon, GPRS Logoff) which informs it further to the GR. The HLR makes an inquiry into the GR in the case of an MT call on subscribers capable of transiting to the GPRS state.

15 5) The SGSN detects that the MS has departed from the GPRS state (e.g. because it does not acknowledge the transmitted data packets). This kind of situation may arise when the battery of the MS runs out before it has time to signal its departure. The SGSN signals the information to the HLR or to the GR as in steps 2 to 4.

20 As an alternative to the above, any other method may be used by means of which the HLR obtains information from the GPRS on the MS registering in or out.

25 The signalling diagram of Figure 3 illustrates more exactly one method for producing the MS presence/absence information in the HLR by GPRS Logon and Logoff procedures, and for processing an MT call.

30 When transiting from the GSM state to the GPRS state, the MS registers into the GPRS network by the GPRS Logon procedure. This includes an authentication procedure in which the HLR (and/or GR) participates, as

35 well. It may be deduced from this authentication

procedure that the MS has assumed the GPRS state and it is no longer available for normal GSM services. As a result of this, the HLR updates in the subscriber data that the mobile subscriber (MS) is not available (MS Detached) and possibly the reason (GPRS Logon) as well. If then an MT call arrives from the PSTN to the MS, the MSC makes an HLR inquiry and receives in response "the MS not available" as in the case of Figure 2. At some stage the MS registers from the GPRS network by a Logoff procedure in which the SGSN and the GGSN are signalled that they can delete their information relating to the MS. At the same time the GSM informs either directly the HLR or then the GR which, in turn, informs the HLR. The HLR updates in the subscriber data that the mobile subscriber (MS) is again available (MS Attached).

Figure 4 is a signalling diagram illustrating the third embodiment of the invention where the MS is transmitted information via the GPRS network on that the MS is about to receive an MT call in the GSM network. In Figure 4 the MS first registers into the GPRS network by the GPRS Logon procedure, whereby the HLR is updated information on that the MS is not available via normal GSM paging channels because it is in the GPRS state. This procedure is similar to what was explained above in connection with Figure 3. Alternatively, any method can be used with which information is updated in the HLR on that the MS is in the GPRS network. The MSC receives an MT call from the PSTN to said MS. The MSC makes a normal routing information inquiry into the HLR. The HLR detects in the subscriber data that the MS is registered into the GPRS network. As a result of this information, the HLR informs the MS via the GPRS network that the MS is about to receive a paging via the GSM channels. This

notification may be transmitted in several different ways, some of which will be explained in more detail below.

5 According to the third embodiment of the invention, the HLR sends a notification to the MS via the GPRS network that it is receiving an MT call on GSM channels. This may be carried out when the HLR has information or it receives information by an inquiry made into the GPRS network that the MS is in the GPRS
10 network. The HLR may also send via the GPRS network information on the MT calls whenever the MS has a right to GPRS services, regardless of whether the MS is in the GPRS network or not. In that case the HLR does not need presence/absence information but it is only in the
15 GPRS network as normal. If the MS is not in the GPRS network, the GPRS network cannot forward the notification but it will be "lost". If the MS is in the GPRS network, the network transmits the notification to the destination. In both cases the GSM has continued
20 call set-up on GSM channels.

In the embodiment of Figure 4, it is assumed that the HLR also contains the address of the support node that serves the MS. In that case the HLR with a connection to the GPRS support nodes (e.g. via the SS7
25 system) may send to the serving support node a data packet informing of the incoming call. Alternatively, the HLR may send to the gateway support node a data packet with the MS data network address or some general address on the basis of which the GGSN can route the
30 data packet to the service support node SGSN. In that case the address has to be stored in the HLR or the HLR has to be able to retrieve it by a GR inquiry. A further alternative is that the HLR informs the GR of an incoming call to a specific IMSI, whereby the GR
35 generates and transmits a data packet (containing the

notification according to the invention) provided with the MS data network address to the service support node SGSN either directly or via the gateway support node GGSN.

5 When information of an incoming GSM call has been (by some appropriate way) forwarded to the serving support node, it sends a data packet on the packet radio channel to the mobile station informing of the MT call on GSM channels. In this way the MS is aware of
10 the incoming MT call and may start to monitor GSM paging channels. This may be unconditional, or the mobile station of the user may be given the opportunity to choose if the MT call is received or not. The MS may stay in the GPRS state, for example, if it has an
15 ongoing active data transfer stage that is not to be interrupted.

 If the MS transits to the GSM state, the support node SGSN should also be aware of it so that it can interrupt transmission via the GPRS channels. In
20 the simplest case the serving support node SGSN automatically interrupts the transmission of information on the GPRS channel after having sent the notification of the incoming call according to the invention.

25 Another alternative is that the serving SGSN continues its transmission and interrupts the transmission only after having found out that the MS does not respond.

 Still another alternative is that the MS, when
30 transiting temporarily from the GPRS state, signals via the GPRS channel to the serving support node SGSN that data packets may not be transmitted to it as it is busy elsewhere. The serving SGSN (or some other unit in the GPRS network) may buffer or discard the data received
35 in the meanwhile. In the last mentioned case the data

will not be lost altogether as the upper level of end to end connection protocols attend to retransmitting the data packets if the MS does not acknowledge them.

5 After having sent a notification via the GPRS network, the HLR sends a normal inquiry response to the MSC containing the roaming number of the mobile station. After this the call-set up for the MS, which has started to monitor GSM paging channels, will proceed according to ordinary GSM signalling on GSM channels.

10 The figures and the specification relating thereto are only intended to illustrate the present invention. In its details, the invention may vary within the scope and spirit of the attached claims.

Claims

1. A digital mobile communication system comprising

5 a mobile communication network containing a mobile services switching centre (MSC), base station systems (BSS,BTS), and a subscriber database (HLR) for maintaining subscriber data and location data of mobile communication network subscribers,

10 a packet radio network containing packet radio support nodes (SGSN), each of which is connected to the mobile communication network and to one or more of the remaining packet radio support nodes, and at least one gateway support node (GGSN) which provides an access
15 point for an external data network or to another packet radio system,

first control channels which are allocated to the use of the mobile communication network in base station systems,

20 second control channels which are allocated to the use of the packet radio network in base station systems,

a mobile terminal equipment (MS) having a first operating state where it monitors said first control channels, and a second operating state where it
25 monitors said second control channels,
c h a r a c t e r i z e d i n t h a t

the subscriber database (HLR) of the mobile communication network has information on that the
30 mobile terminal equipment (MS) is not available via the first control channels when the mobile terminal equipment (MS) is in said second operating state.

2. A mobile communication system according to claim 1, c h a r a c t e r i z e d i n t h a t

35 the mobile terminal equipment (MS) is arranged

to signal on said first control channels the absence or presence information, respectively, to the mobile communication network when it moves from the first operating state to the second operating state or, correspondingly, from the second operating state to the first operating state,

the mobile communication network is arranged to update the absence or presence information signalled by the mobile terminal equipment (MS) to the subscriber database (HLR).

3. A mobile communication system according to claim 1 or 2, characterized in that

the subscriber database is arranged to receive or inquire the presence/absence information of the mobile terminal equipment (MS) of the packet radio network.

4. A mobile communication system according to claim 3, characterized in that

the packet radio network comprises a first registration procedure which the mobile terminal equipment (MS) performs upon transition to the second operating state, and a second registration procedure which the mobile terminal equipment performs via the second control channels when it departs from the second operating state,

in response to performing the first registration procedure in the packet radio network, the mobile communication network subscriber database (HLR) updates in the subscriber data that the mobile terminal equipment (MS) is not available via the first control channels,

in response to performing the second registration procedure in the packet radio network, the mobile communication network subscriber database (HLR) updates in the subscriber data that the mobile

termination equipment (MS) is available via the first control channels.

5. A mobile communication system according to claim 1, 2, 3 or 4, characterized in that

5 information on that the mobile terminal equipment has registered into the packet radio network is associated with the information that the mobile terminal equipment is not available via the first control channels.

10 6. A mobile communication system according to claim 1, 2, 3, 4 or 5, characterized in that

the mobile services switching centre (MSC), which receives a mobile-terminating call, is arranged to make an inquiry into the subscriber database (HLR),

15 the mobile services switching centre (MSC) is arranged to interrupt call set-up or make call forwarding when the subscriber database (HLR) has information that the mobile terminal equipment is not available via the first control channels.

20 7. A mobile communication system according to any one of claims 1 to 5, characterized in that

the mobile services switching centre (MSC), which receives a mobile-terminating call, makes an inquiry into the subscriber database (HLR),

25 in response to the information that the mobile terminal equipment (MS) is not available via the first control channels and registered into the packet radio network, the subscriber database is arranged to transmit a notification to the mobile terminal equipment (MS) via the packet radio network that it is about to receive a call in the mobile communication network,

30 the mobile communication network continues

call set-up via the first control channels.

8. A mobile communication system according to claim 1, characterized in that

5 said information comprises information that the mobile terminal equipment is authorized to operate or capable of operating in the packet radio network.

9. A mobile communication system according to claim 8, characterized in that

10 the mobile services switching centre (MSC), which receives a mobile-terminating call, is arranged to make an inquiry into the subscriber database (HLR), in response to the information that the mobile terminal equipment (MS) is authorized to operate or capable of operating in the packet radio network, the
15 subscriber database is arranged to transmit a notification to the mobile terminal equipment (MS) via the packet radio network that it is about to receive a call in the mobile communication network,

20 the mobile communication network continues call set-up via the first control channels.

10. A mobile communication system according to claim 7 or 9, characterized in that

25 in response to receiving said notification via the packet radio network, the mobile terminal equipment (MS) transits into the first operating state to monitor the first control channels.

11. A mobile communication system according to claim 10, characterized in that

30 the packet radio network is arranged to interrupt a data transmission to the mobile terminal equipment (MS) in one of the following ways:

- in response to sending said notification to the mobile terminal equipment,
- in response to a cease transmission message
35 sent by the mobile terminal equipment,

- in response to the mobile terminal equipment not acknowledging the sent information.

5 12. A method for processing a mobile-terminating call in a digital mobile communication system comprising a mobile communication network; a packet radio network containing packet radio support nodes, each of which is connected to the mobile communication network which provides a radio interface for the packet radio network; first control channels
10 allocated to the use of the mobile communication network in the radio interface; second control channels allocated to the use of the packet radio network in the radio interface; and a mobile terminal equipment having a first operating state where it monitors said first control channels, and a second operating state where it
15 monitors said second control channels,
c h a r a c t e r i z e d by

updating in the subscriber database of the mobile communication network information on that the
20 availability of the mobile terminal equipment via the first control channels is uncertain when the mobile terminal equipment transits from the first to the second operating state,

updating in the subscriber database of the
25 mobile communication network information on that the mobile terminal equipment is available via the first control channels when the mobile terminal equipment returns from the second to the first operating state,

30 receiving a mobile-terminating call in the mobile communication network,

making an inquiry into said subscriber database,

interrupting call set-up or making call
35 forwarding if the subscriber database comprises information that the availability of the mobile

terminal equipment is uncertain.

13. A method for processing a mobile-terminating call in a digital mobile communication system comprising a mobile communication network; a packet radio network containing packet radio support nodes, each of which is connected to the mobile communication network which provides a radio interface for the packet radio network; first control channels allocated to the use of the mobile communication network in the radio interface; second control channels allocated to the use of the packet radio network in the radio interface; and a mobile terminal equipment having a first operating state where it monitors said first control channels, and a second operating state where it monitors said second control channels,
c h a r a c t e r i z e d by

updating in the subscriber database of the mobile communication network information on that the mobile terminal equipment is in the packet radio network and its availability via the first control channels is uncertain when the mobile terminal equipment transits from the first to the second operating state,

receiving a mobile-terminating call in the mobile communication network,

making an inquiry into said subscriber database,

in response to said information in the subscriber database (HLR), transmitting a notification to the mobile terminal equipment via the packet radio network that it is about to receive a call in the mobile communication network,

the mobile terminal equipment transiting to monitor the first control channels in response to receiving the notification,

continuing call set-up in the mobile communication network via the first control channels.

14. A method for processing a mobile-terminating call in a digital mobile communication system comprising a mobile communication network; a packet radio network containing packet radio support nodes, each of which is connected to the mobile communication network which provides a radio interface for the packet radio network; first control channels allocated to the use of the mobile communication network in the radio interface; second control channels allocated to the use of the packet radio network in the radio interface; and a mobile terminal equipment having a first operating state where it monitors said first control channels, and a second operating state where it monitors said second control channels, characterized by

maintaining in the subscriber database of the mobile communication network information on that the mobile terminal equipment is capable of operating or authorized to operate in the second operating state,

receiving a mobile-terminating call in the mobile communication network,

making an inquiry into said subscriber database,

in response to said information in the subscriber database (HLR), transmitting a notification to the mobile terminal equipment via the packet radio network that it is about to receive a call in the mobile communication network,

the mobile terminal equipment transiting to monitor the first control channels in response to receiving the notification,

continuing call set-up in the mobile communication network via the first control channels.

15. A method according to claim 12, 13 or 14,
c h a r a c t e r i z e d by

5 signalling from the mobile terminal equipment
to the mobile communication network on said first
control channels absence or presence information,
respectively, when the mobile terminal equipment
transits from the first operating state to the second
operating state or, correspondingly, from the second
operating state to the first operating state,
10 updating absence or presence information in
the subscriber database.

16. A method according to claim 13, 14 or 15,
c h a r a c t e r i z e d by

15 making the first registration procedure via
the second control channels to the packet radio network
when the mobile terminal equipment transits to the
second operating state,

20 making the second registration procedure via
the second control channels in the packet radio network
when the mobile terminal equipment departs from the
second operating state,

25 updating absence or presence information,
respectively, in the subscriber database of the mobile
communication network in response to making the first
or, correspondingly, the second registration procedure
in the packet radio network.

1/4

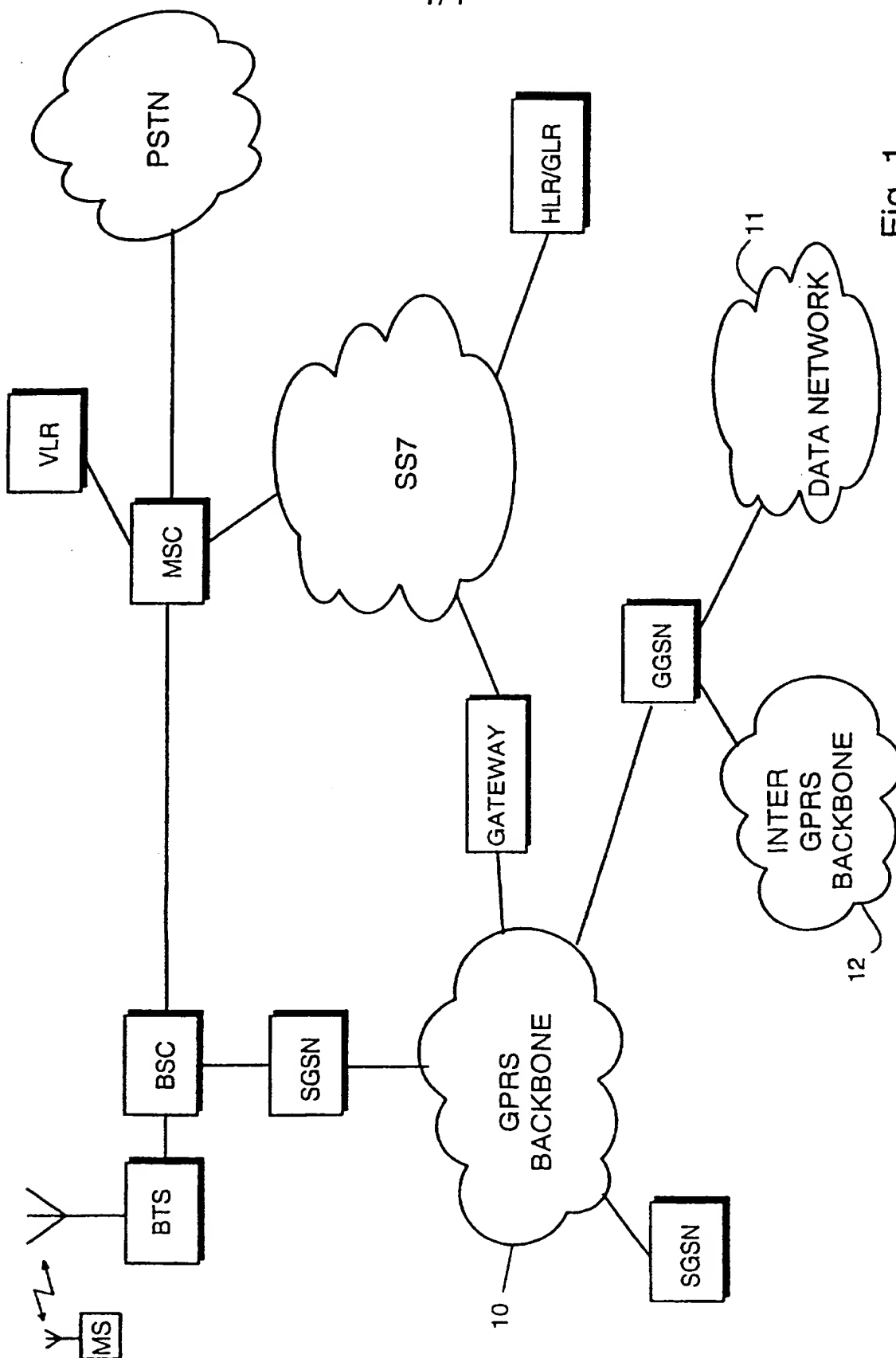


Fig. 1

2/4

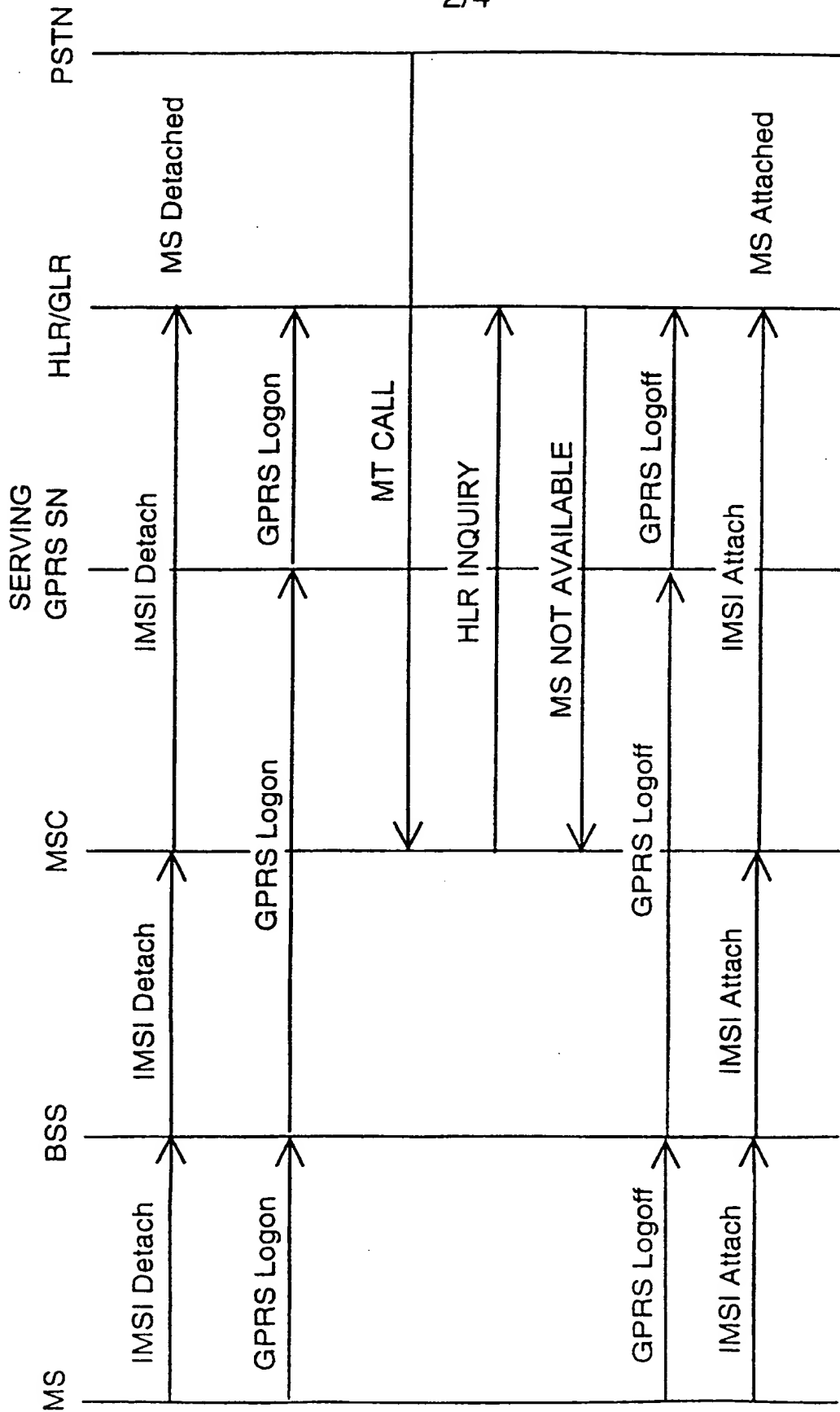


Fig. 2

3/4

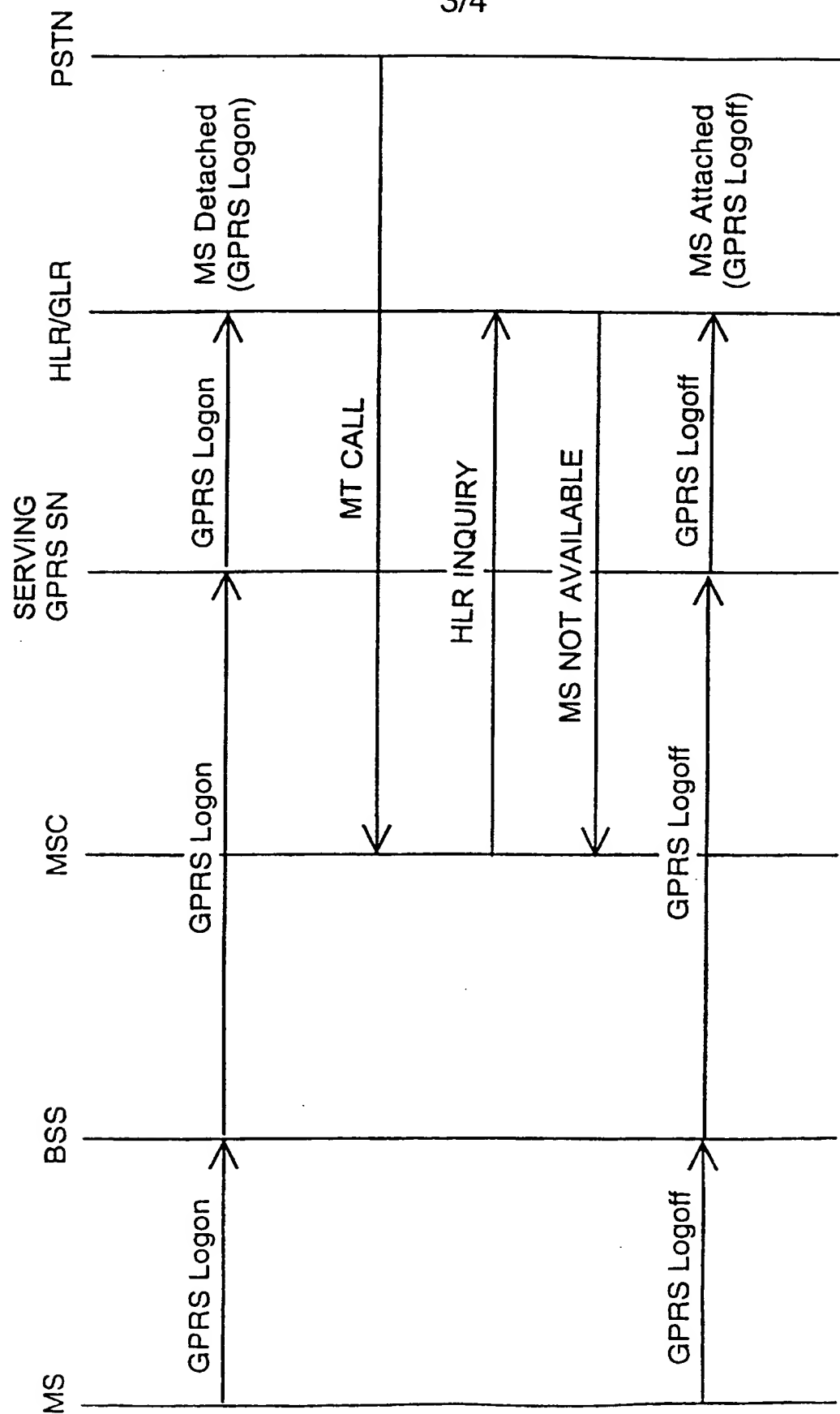
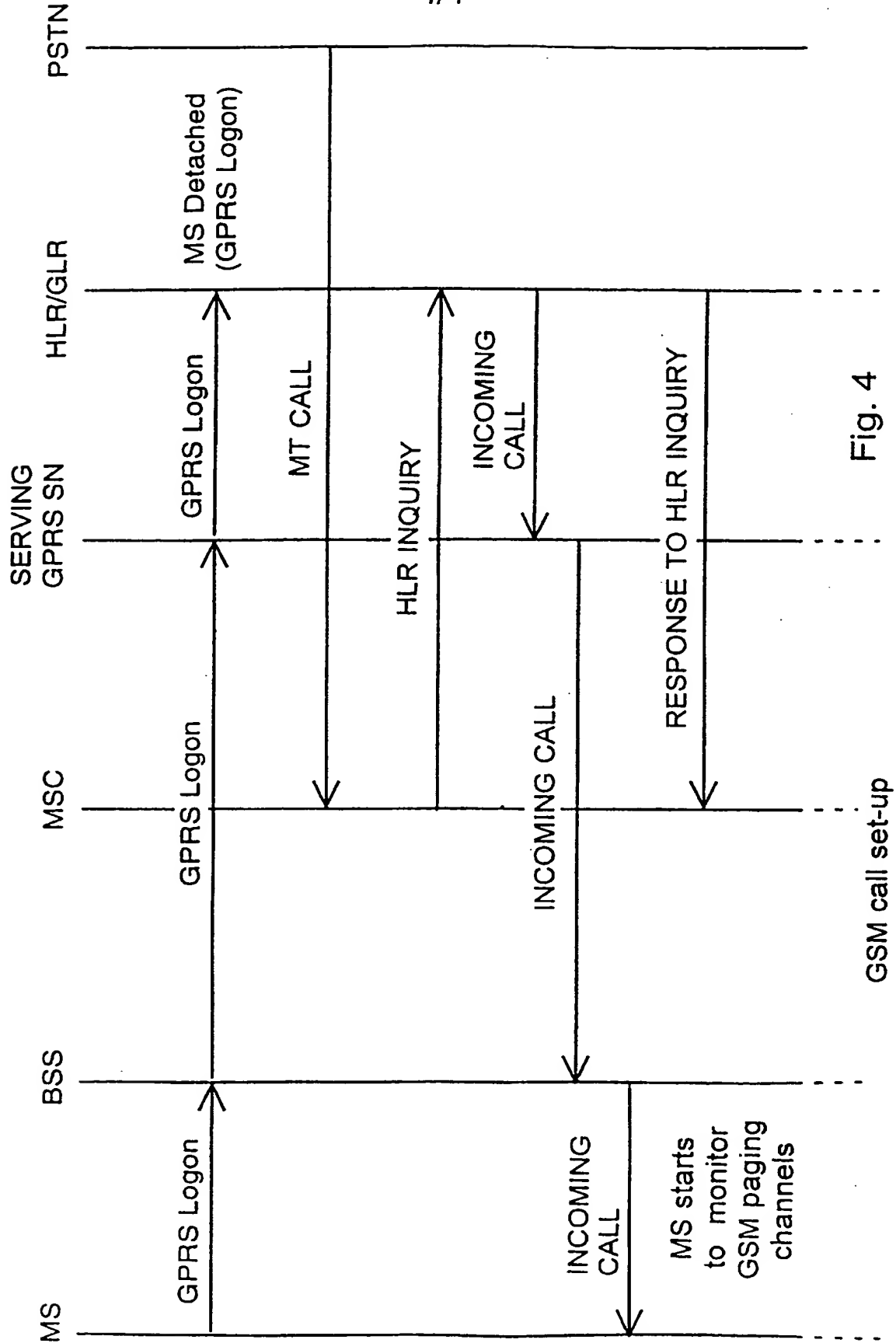


Fig. 3

4/4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 97/00020

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04Q 7/22, H04L 12/56

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP, 0642283, A2 (NOKIA MOBILE PHONES LTD.) 8 Mar 1995, (08.03.95); abstract; figs. 4-7, fig. 15; p. 2, l. 46 - p. 3, l. 21; p. 4, ll. 21-37; p. 4, ll. 50-53; p. 5, ll. 13-30; p. 5, ll. 39-40; p. 6, ll. 34-35; p. 9, ll. 31-35;	1-6,8
Y	--	7,9-16

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

19 June 1997

Date of mailing of the international search report

25 -06- 1997

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 97/00020

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	<p>IEEE Transactions on Vehicular Technology, vol 42, no. 1, Feb 1993, New York, US, pp. 1-13. N.M. Mitrou et al.: 'Voice and Data Integration in the Air-Interface of a Microcellular Mobile Communication System'</p> <p>p. 2, left col., ll. 18-24; p. 2, right col., ll. 26-32; p. 5, left col., ll. 13-21, ll. 36-41; p. 6, left col., ll. 10-25; p. 6, right col., l. 20- p. 7, left col., l. 9</p> <p>--</p>	7,9-16
A	<p>WO, 9516330, A1 (TELEFONAKTIEBOLAGET LM ERICSSON) 15 June 1995, (15.06.95); abstract; p. 3, l. 25 - p. 4, l. 9; p. 16, ll. 3-6; p. 18, ll. 3-14, ll. 32-34; p. 20, ll. 19-30; claims 50-51</p> <p>--</p>	1-16
A	<p>US 4887265 A (K.A. FELIX), 12 December 1989 (12.12.89), figures 1,5, abstract</p> <p>--</p>	1-16
A	<p>WO 9520283 A1 (NOKIA TELECOMMUNICATIONS OY ET AL), 27 July 1995 (27.07.95), page 8, line 13 - line 21; page 18, line 8 - line 18, abstract</p> <p>--</p>	1-16
A	<p>WO 9528063 A2 (NOKIA TELECOMMUNICATIONS OY), 19 October 1995 (19.10.95), page 8, line 20 - line 23; page 12, line 12 - line 20; page 20, line 5 - line 15, abstract</p> <p>-- -----</p>	1-16

INTERNATIONAL SEARCH REPORT

Information on patent family members

03/06/97

International application No.

PCT/FI 97/00020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4887265 A	12/12/89	AT 146927 T CA 1309480 A DE 68927575 D EP 0332818 A,B SE 0332818 T3 EP 0746172 A ES 2095829 T JP 1274524 A JP 7105975 B	15/01/97 27/10/92 00/00/00 20/09/89 04/12/96 01/03/97 02/11/89 13/11/95
WO 9520283 A1	27/07/95	AU 1419095 A CN 1138929 A EP 0740876 A FI 94700 B,C FI 940314 D	08/08/95 25/12/96 06/11/96 30/06/95 00/00/00
WO 9528063 A2	19/10/95	AU 2778795 A CN 1145156 A EP 0754395 A FI 95984 B,C FI 941652 A	30/10/95 12/03/97 22/01/97 29/12/95 09/10/95

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 97/00020

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 97/00020

I: The invention as claimed in claims 1-11 and 14-16 refers to that the subscriber database has information on that the mobile terminal equipment is not available for calls, when the mobile terminal equipment is in packet mode.

II: The invention as claimed in claims 12 and 13 refers to that the subscriber database has information on that the availability for calls of the mobile terminal equipment is uncertain, when the mobile terminal equipment is in packet mode.

These groups of inventions are not so linked as to form a single general inventive concept (PCT Rule 13.1). There is no technical relationship among those inventions involving one or more of the same or corresponding technical features within the meaning of PCT Rule 13.2.